SECTION 15250
MECHANICAL INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary General Conditions, apply to this section.

1.2 SUMMARY

A. The work specified in this section includes providing material, equipment, labor and services necessary for the installation of the surface insulation for piping, ductwork, and HVAC equipment as shown on the drawings and as herein specified.

B. Related Sections:
   1. Division 15, Section 15050, “Piping System”.

C. Where a conflict occurs between this section and other related sections, this technical section of the specification shall take precedence.

1.3 REFERENCES

A. The publications listed in this specification form a part of this specification to the extent referenced. If the referenced publications have been revised prior to the Contract award, the latest edition or revision shall be substituted for the referenced document.

B. Equipment, materials, workmanship, and installation shall be in compliance with the current edition of codes, ordinances, regulations, and requirements of the local, county, state and national bodies having jurisdiction.

C. Published standards, texts, recommended methods of trade, and industry or governmental organizations shall apply to work included in the design documents.

D. American Society for Testing and Materials (ASTM).
   1. ASTM C 411 and ASTM E 84

E. National Fire Protection Association (NFPA).
   1. NFPA 255 (1990), Test of Surface Burning Characteristics of Building Materials.

F. Underwriters Laboratory (UL).
   1. UL 723, The Standard for Tests for Surface Burning Characteristics of Building Material.

1.4 SUBMITTALS

A. Submittals shall conform to the requirements of General and Supplementary General Conditions.

B. Submit a schedule, which shows proposed manufacturer, insulation type, thickness, density, jacket material, and installation instructions for each type of piping, ductwork, and equipment to be insulated.

C. Submit manufacturer's standard data sheets for each proposed type of insulation, accessory, and compound. Data sheets shall show complete compliance with specified requirements including, but not limited to, K-factor, flame spread, and smoke development.

D. Submit samples of each type of proposed insulation complete with proposed jacket and clearly identify the system(s) where the insulation will be used.

1.5 QUALITY ASSURANCE

A. Work shall be executed by skilled mechanics under the direction of a qualified supervisor thoroughly knowledgeable and experienced in the basic principles required for application of insulation, protective coatings, and accessories therein.

B. Fire Performance Characteristics:
   1. Insulation including, but not limited to, fitting covers and jackets shall have composite surface burning characteristic ratings as tested by ASTM E 84, UL 723, or NFPA 255 not exceeding the following:
      a. Flame Spread: 25.
      b. Smoke Developed: 50.
   2. Composite shall include insulation, jacketing, and adhesive used to secure jacketing or facing. Accessory items such as adhesive, mastic, cement, tape, and cloth, and indoor polyvinyl chloride (PVC) jacketing and fitting covers shall have the same component ratings as specified above.
   3. Proposed materials, compounds, and accessories shall conform to these requirements. Products or their shipping cartons shall bear the UL label indicating that flame and smoke ratings do not exceed the above criteria.

C. Insulation packages and containers shall be labeled to certify that the products are "ASBESTOS FREE".

PART 2 - PRODUCTS

2.1 GENERAL

A. Insulation materials shall be as specified for piping, ductwork and equipment including adhesives, fasteners, coverings, etc., for a complete insulating system.

2.2 PIPE INSULATION

A. Premolded Fibrous Glass (PFG/ASJ):
   1. Provide fibrous glass in longitudinally-split-premolded sections covered with factory-applied all-service (all-purpose) jacket. Jacket shall be laminated white kraft paper reinforced foil and shall have integral pressure sealing adhesive lap strip, with nominal 3 to 5 pcf density, K-factor of 0.23 to 0.29 Btu per inch per hour per square foot per degree Fahrenheit at 75°F, and maximum 0.02 perm-inch water vapor permeability, for pipe service temperature up to 850°F. Unless noted on drawings, provide one layer of insulation up to 4-inch thickness and up to 600°F.
   2. Pipe Insulation:
      a. CertainTeed Corp., "Snap*On (ASJ-SSL)"
      b. Knauf, "Pipe Insulation w/ASJ-SSL"
      c. Manville, "Micro-Lok AP-T Plus"
      d. Owens-Corning, "Fiberglass ASJ/SSL-II"
   3. Block and Board Insulation: May be used up to 450°F for fabricated fittings:
      a. CertainTeed Corp., "IB 300 ASJ"
      b. Knauf, "Insulation Board ASJ 3PCF"
      c. Manville, "814 Spin-Glass w/AP"
      d. Owens-Corning, "Type 703 ASJ"
   4. Semi-Rigid Roll Insulation: May be used for fabricated fittings, valves, and tanks 10 inches in diameter and above, for service up to 650°F.
      a. CertainTeed Corp., "Snap*Wrap Tank and Pipe/ASJ"

b. Knauf, "Pipe and Tank/ASJ"
c. Manville, "Pipe and Tank/AP"
d. Owens-Corning, "Pipe and Tank/ASJ"

5. Flexible Glass Fiber Fitting Insulation Inserts (FFI):
   a. Provide fibrous glass inserts with a thermal conductivity K-factor of 0.26 to 0.28 Btu per inch per hour per square foot per degree Fahrenheit at 75°F (for use with manufacturer's PVC fitting covers).
   b. Acceptable Manufacturers:
      1) CertainTeed Corp., "Snap*Form Insulation Inserts" (-120°F to 500°F)
      2) Knauf, "Proto Fiber Glass Insert" (0°F to 800°F)
      3) Manville, "Hi-Lo Temp Insert" (0°F to 450°F)
      4) Owens-Corning, "TIW" (0°F to 1,000°F)
6. Rigid Fiberglass Inserts (RFI):
   a. Molded or routed pipe fitting insulators consisting of two matching half-sections, made from inert, 4 to 6 pcf density glass fiber and a thermosetting binder. Maximum thermal conductivity K-factor of 0.33 Btu per inch per hour per square foot per degree Fahrenheit at 200°F.
   b. Acceptable Manufacturers:
      1) Pro-Tec-T-Kote, "#1-500 Fiberglass Fitting Covering" or acceptable substitute.
7. Glass Cloth Jacket (GCJ):
   a. Fiberglass Lagging Fabric:
      1) Alpha-Maritex or acceptable substitute.
   b. Rewettable Fiberglass Lagging Fabric:
      1) Alpha-Maritex or acceptable substitute.
8. Lagging Adhesive:
   a. Childers Products Co., "Chil-Lag (CP-52)"
   b. Foster Div., H.B. Fuller Co., "No. 81-42W LAGFAS"
9. Insulation Joint Sealant/Lap Adhesive:
   a. Childers Products Co., "Chil-Stix FRN (CP-82), or CLEAR (CP-85)"
   b. Foster Div., H.B. Fuller Co., "No. 85-15 STIC-SAFE Adhesive" or "No. 85-20 SPARK-FAS Adhesive"
10. Insulating/Finishing:
    a. Pabco Div., Fibreboard Corp., "Pabcote and No. 127"
    b. Ramco Insulation, Inc., "Ramcote 1200" (not for use with aluminum)
11. Exterior Vapor Barrier:
    a. Childers Products Co., "Chil-Pruf NF (CP-21)" or acceptable substitute.
12. Interior Vapor Barrier Coating:
    a. Foster Div., H.B. Fuller Co., "VAPOR-FAS No. 30-15 (brush), No. 30-25 (trowel or glove)" or acceptable substitute.

B. Premolded Calcium Silicate (PCS):
1. Hydrous calcium silicate, nominal 14 to 15 pcf density and K-factor of 0.42 Btu per inch per hour per square foot per degree Fahrenheit at 200°F, for service up to 1,200°F, tested per ASTM C 411. Provide single layer thicknesses up to 3 inches and 550°F. Insulation shall not cause or promote stress corrosion cracking of authentic stainless steel.
2. Pipe Insulation:
   a. Manville, "Thermo-12/Blue"
   b. Owens-Corning, "Kaylo Pink"
   c. Pabco Div., Fibreboard Corp., "Super Caltemp Gold"
3. Sheet and Block Insulation: May be used for fabricated fittings:
   a. Manville, "Thermo-12/Blue"
   b. Owens-Corning, "Kaylo Pink (block and V-grooved)"
   c. Pablo Div., Fiberboard Corp., "Super Caltemp Gold (flat and scored)"
4. Insulation Joint Sealant/Adhesive: Indoors only:
   a. Childers Products Co., "Fibrous Adhesive (CP-97) 50°F to 800°F"

b. Foster Div., H.B. Fuller Co., "Fibrous Adhesive 40°F to 850°F No. 81-27" (brush) "No. 81-93" (trowel)
c. Pablo Div., Fiberboard Corp., "Super Calstick"

5. Lagging Adhesive:
   a. Childers Products Co., "Chil-Seal (CP-50A HV2)"
   b. Foster Div., H.B. Fuller Co., "Lagfas 81-42W"
6. Sizing Adhesive:
   a. Childers Products Co., "Chil-Lag (CP-52)"
   b. Foster Div., H.B. Fuller Co., "Lagfas 81-42W"
7. Insulation/Finishing Cement:
   a. Pablo Div., Fiberboard Corp., "Pablo No. 127" or acceptable substitute.

C. Premolded Flexible Elastomeric (PFE) and Flexible Elastomeric Sheet (FES):
1. Provide flexible premolded or precut sheet sections of expanded closed-cell elastomeric with factory-applied talc coating on inside surface, with nominal 6 pcf density, K-factor of 0.27 Btu per inch per hour per square foot per degree Fahrenheit at 75°F, and maximum 0.2 perm-inch water vapor permeability, and -40°F to 200°F service temperature. Insulation shall not be used on stainless steel.
2. Pipe Insulation (PFE):
   a. Armstrong World Industries, "AP Armaflex, or Armaflex 2000 (40°F to 200°F)"
   b. Halstead Industrial Products, "Insul-Tube, or Insul-Lock (0°F to 200°F)"
   c. Rubatex Corp., "Rubatex R-180-FS, or Inseal"
3. Flexible Elastomeric Sheet (FES): May be used for fabricated fittings:
   a. Armstrong World Industries, "AP Armaflex Sheet"
   b. Halstead Industrial Products, "Insul-Sheet"
   c. Rubatex Corp., "Rubatex R-1800-FS Sheet"
4. Insulation Joint Sealant/Adhesive:
   a. Armstrong World Industries, "520 Adhesive"
   b. Halstead Industrial Products, "HIP Adhesive"
   c. Rubatex Corp., "373 Adhesive"
5. Finish for exterior only:
   a. Armstrong World Industries, "WB Armaflex Finish"
   b. Halstead Industrial Products,"Protective Coating 67 X 944"
   c. Rubatex Corp., "374 Coating"

D. Removable Reusable Insulation Jacket (RRIJ) for hot valves, flanges, and equipment:
1. Provide fibrous glass or combination glass and ceramic fibrous blanket with an inner and outer water-resistant layer. Provide reusable buckles and straps, lacing eyelets and cord, rings and cord, or hooks and eyes for securing insulation jacket.
2. Provide bottom seam or weep hole for leak detection.
3. On valves, insulation shall include bonnets.
4. Insulation shall be designed for the piping temperature.
5. Acceptable Manufacturers:
   a. Glas-Col, "Heatstop"
   b. Multiglas Products Company, "MULTI COV-R"
   c. Quality Insulation Fabricators, "Heat Holder"
   d. Universal Insulation Products.
   e. Wilson Sales Company.

2.3 JACKETING AND FITTING COVERS

A. PVC Insulation Fitting Covers and Jacketing:
1. Provide premolded PVC insulation fitting covers and jacketing having a white, weather-resistant finish and maximum 0.02 perm-inch water vapor permeability.
2. Jacketing shall be ultraviolet-resistant, 20 mil thickness indoor and 30 mil outdoor and shall be rated for 0°F to 150°F.

3. Jacketing shall meet USDA or FDA requirements where applicable.
4. Acceptable Manufacturers:
   a. Ceel-Co., "Ceel-Tite #320 (indoors), Ceel-Tite #330 (outdoors, 0°F to 150°F)
   b. CertainTeed, "Snap*Form"
   c. Foster Div., H.B. Fuller Co., "Speedline Smoke-Safe"
   d. Knauf, "Proto Lo SMOKE"
   e. Manville, "Zeston 2000"
5. Acceptable Solvent Adhesives: Do not use regular PVC cement:
   a. Ceel-Co., "Ceel-Co 300" Solvent Welding Adhesive.
   b. Knauf, "Proto" Solvent Adhesive.
   c. Manville, "Perma-Weld" Adhesive.
6. Indoor Colored PVC Jacketing:
   a. Proto Corp., "Lo SMOKE" (20 mil).
   b. Fosters Div. H.B. Fuller Co, "Speedline Smoke-Safe"

B. Aluminum Jackets (ALJ):
1. Weatherproof jackets shall be 0.016-inch thick embossed aluminum, provided with longitudinal Pittsburgh seams and butt joint strips with weatherproof mastic adhesive.
   a. Childers Products, "Lock-On"
   b. Insul-Coustic, "Metal-Clad"
   c. Pablo Div., Fiberboard Corp., "Aluminum Jacketing"
2. Metal Joint Sealant:
   a. Childers Products, "Chil-Byl (CP-76)"
   b. Foster Div., H.B. Fuller, "No. 95-44 Elastolar"
   c. Dow Corning #739 silicone sealant.
3. Stainless Steel Clamps and Strapping:
   a. Panduit Corp., "PAN-STEEL Clamp System"
   b. Insul-Coustic, "(per jacket manufacturer)"
   c. Childers Products, "(per jacket manufacturer)"

2.4 DUCTWORK AND EQUIPMENT INSULATION

A. Flexible Elastomeric Sheet (FES):
1. Provide flat sheets of expanded closed-cell elastomeric, with nominal 6-pcf density, K-factor of 0.27 Btu per inch per hour per square foot per degree Fahrenheit at 75°F, and 0.17 to 0.2 perms. per inch water vapor permeability and -40°F to 200°F service temperature.
2. Flexible Elastomeric Sheet (FES):
   a. Armstrong World Industries,"AP Armaflex Sheet"
   b. Halstead Industrial Products, "Insul-Sheet"
   c. Rubatex Corp., "Rubatex R-1800-FS Sheet"
3. Insulation Joint Sealant/Adhesive:
   a. Armstrong World Industries, "520 Adhesive"
   b. Halstead Industrial Products, "HIP Adhesive"
   c. Rubatex Corp., "373 Adhesive"
4. Finish: For exterior only:
   a. Armstrong World Industries, "Armaflex"
   b. Halstead Industrial Products, "Protective Coating 67 X 944"
   c. Rubatex Corp., "374 Coating"

B. Flexible Fibrous Glass Blanket (FFG):
1. Provide fibrous glass blanket with factory-applied flame retardant aluminum foil (FSK-Type) vapor barrier facing with kraft reinforced laminate, with nominal 1 pcf density, K-factor of 0.27 Btu per inch per hour per square foot per degree Fahrenheit at 75°F, and 0.02 perm-inch water vapor permeability, for service temperature up to 250°F.
   a. CertainTeed, "Standard Duct Wrap, FSK 1 PCF"

b. Knauf, "Duct Wrap, FSK, 1 PCF"
c. Manville, "Microlite 100, FSK"
d. Owens-Corning, "All Service Wrap, Type 100, FSK"

C. Semi-Rigid Fibrous Glass Blanket (SFG):
1. Provide fibrous glass factory-adhered to all-service or aluminum foil jacket. Jacket shall be a lamination of aluminum foil, glass fabric reinforcing, and heavy duty kraft reinforced laminate outer cover, with nominal 3 pcf density, K-factor of 0.22 to 0.26 Btu per inch per hour per square foot per degree Fahrenheit at 75°F, and 0.02 perm-inch water vapor permeability, for a service temperature up to 450°F.
a. CertainTeed, "IB 300 ASJ or FSK"
b. Knauf, "Insulation Board 3 PCF ASJ or FSK"
c. Manville, "814 Spin-Glas, AP or FSK"
d. Owens-Corning, "Type 703, ASJ or FSK"

D. Rigid Fibrous Glass Board (RFG):
1. Provide preformed fibrous glass board with factory-applied all-service vapor barrier jacket. Jacket shall be lamination of aluminum foil, glass fabric reinforcing, and heavy duty kraft reinforced laminate outer cover, with nominal 6 pcf density, K-factor of 0.23 Btu per inch per hour per square foot per degree Fahrenheit at 75°F, and 0.02 perm-inch water vapor permeability, and a service temperature up to 450°F.
a. CertainTeed, "IB 600 ASJ or FSK.
b. Knauf, "Insulation Board 6 PCF ASJ or FSK.
c. Manville, "817 Spin-Glas, AP or FSK.
d. Owens-Corning, "Type 705, ASJ or FSK.

PART 3 - EXECUTION

3.1 GENERAL

A. Skilled workmen regularly engaged in this type of work shall apply insulation in a workmanlike manner.

B. Complete tests and inspections of the work to be insulated before covering or insulation are applied.

C. Pipe, fittings, valves, ducts, equipment, and other items to be insulated shall be dry and thoroughly cleaned of foreign matter before insulation is applied.

D. Nameplates, stamping plates, and other identification plates on equipment shall not be covered.

E. Insulation at hand holes, access doors, or other openings, and adjacent to flanges, unions, and valves shall be neatly tapered with cement or vapor barrier cement as required, and sealed to allow access to and removal of unions, flanges, and bolts without injury to adjacent covering.

F. Wherever new work connects into existing systems provide a smooth and neat transition between new and existing insulations. Repair pipe and duct insulation damaged by new construction.

G. Apply sizing adhesive at insulation and fittings without integral vapor barrier in exposed areas such as utility, basement, and storage rooms as preparation for painting.

H. Ends of insulation shall be sealed off. Spray paint is not acceptable. There shall be no exposed ends.

I. Insulation not properly installed shall be removed and replaced or repaired by Contractor.

J. Provide drop cloths, canvas, or other protection for machinery and other surfaces to protect surfaces from splatter paste, water, etc., while covering is being applied. Spots of paste, etc., on insulation or equipment, shall be removed and surfaces cleaned before painting.

K. Insulation on hot surfaces shall be applied while surfaces are hot to avoid breaking of insulation during expansion of piping. Insulation may be applied to cold (but dry) surfaces, however, if leaks develop after application of insulation, or insulation cracks due to expansion, insulation shall be removed and replaced.

L. On cold surfaces where a vapor barrier must be maintained, insulation shall be applied with a continuous, unbroken moisture and vapor seal. Hangers, supports, anchors, or other projections that are secured to cold surfaces shall be coated with Morels no drip, and insulated and vapor sealed to prevent condensation.

M. Surface finishes shall be extended in such a manner as to protect raw edges, ends, and surfaces of insulation.

N. Pipe or duct insulation shall be continuous through walls, ceiling or floor openings, and sleeves, except where not allowed by fire stop or fire separation systems.

O. Insulation damaged by water shall be removed and replaced with new insulation at no increase in Contract Price.
   1. If the insulation manufacturer certifies in writing that the insulation performance is undamaged when dried, the Contractor may remove the wet insulation from the piping, thoroughly dry it, then reinstall it on clean and dry piping at no increase in Contract Price.
   2. The Construction Manager shall review the manufacturer's written certification and the extent of the work.

3.2 PIPE INSULATION

A. General:
   1. Ends of adjacent lengths of pipe insulation shall be firmly butted together, taped, and cemented vapor tight.
   2. Pipe insulation shall be in sectional form. When segmental forms are required, segments shall be closely fitted to the curved surfaces to be insulated.
   3. Provide removable insulation access sections to permit removal of strainer baskets, unions, and access to flanges without adjacent insulation damage. Access sections shall be capable of removal and replacement with no insulation damage. Access section shall include metal vessel covers, fasteners, flanges, frames, and other required accessories.
   4. Insulation shall be installed on cold water lines and include compression chambers and urinal flush valve supplies other than the exposed chrome flush pipe.
   5. Pre-insulated pipe supports are to be supplied and installed by the pipe erector. Utilize a wet-lag butt joint on cold service lines with taped joint. Use taped joint only on hot service lines.
   6. Do not insulate unions except those subject to sweating (i.e., chilled water, cold water, etc.). Terminate insulation on both sides of unions with 45-degree circumferential taper and finish with insulating cement.
   7. Insulation on horizontal down spout shall include the roof drain bowl.
   8. Condensate drain piping from cooling coils shall be insulated.
   9. Insulate piping connecting the air separators and the compression/expansion tanks.
   10. Insulation shall be installed on new lines in buildings and not buried directly in earth. Underground piping in enclosed trenches, pipe tunnels, crawl spaces, pits, and vaults shall be insulated unless specifically excluded.

11. Covering shall be neatly finished at pipe hangers. Insulation on pipes that sweat shall be continuous through wall and ceiling openings and sleeves.
12. Staples are permitted on hot piping insulation only. Longitudinal laps seams shall be installed with Monel flare type staples 2 inches on center. Apply butt strips with coated or dull side out and staple. No staples shall be used on cold piping or refrigerant lines. Screws shall not be permitted for installing metal jacketing over cold piping. Only bands shall be permitted to prevent vapor barrier from being penetrated.
13. Protective Jacketing:
    a. Aluminum jacketing shall be used to cover insulated piping located outside or exposed to Class-clean air streams.
    b. PVC jacketing shall be used to cover insulated piping located in the equipment rooms exposed to Class-clean air streams, and on exposed piping. Jacketing shall only be required on piping installed below 10'-0" above finished floor, and anywhere that the finished insulation might be subject to damage (Example: insulated piping installed across the top of an air handler that might be walked on, etc.).
    c. All-service jacketing shall be used to cover concealed piping.

B. Pipe Insulation Schedule:

Piping System Description	Minimum Insulation Thickness	Type of Insulation	Jacket Cover
1. Chilled Water (CHW): (40°F to 60°F), Process Water (PW), Sanitary Water Cold (SWC): (40°F to 60°F) and			
Run outs not exceeding 10 ft.			
In length up to 2 inches	1 inches	PFG	ASJ
Pipe through 2 inch	1 inch	PFG	ASJ
2-1/2 inches thru 4 inches	1-1/2 inches	PFG	ASJ
Over 4 inches	2 inches	PFG	ASJ

Pipe Insulation Schedule continued

Piping System Description	Minimum Insulation Thickness	Type of Insulation	Jacket Cover

Exception to the above chilled water piping insulation requirements is the **Sensible Chilled Water** (CHWS & R (1)) piping system in the **Target Building**. In the Target building only, insulation thickness requirement regardless of pipe size, is typically reduced to ½" thickness maximum unless otherwise indicated on drawings. Insulation type and jacket-cover shall remain the same.

2. Sanitary Water Hot (SWH): (105°F to 140°F) and Sanitary Hot Water (recirculating).			
Run outs not exceeding 10 ft.			
In length up to 2 inches	1 inches	PFG	ASJ
Pipe through 2 inches	1 inch	PFG	ASJ
2-1/2 inches thru 4 inches	1-1/2 inches	PFG	ASJ
Over 4 inches	2 inches	PFG	ASJ
3. Heating Water piping (HWS, HWR), DX Refrigerant Suction & Liquid piping (RS, RL), Technical Cooling Water Piping (Return only when 97°F DIR is located in air conditioned spaces): (80°F to 200°F).			
Run outs not exceeding 10 ft.			
In length up to 2 inches	1 inches	PFG	ASJ

Pipe through 2 inches	1 inch	PFG	ASJ
2-1/2 inches thru 4 inches	1-1/2 inches	PFG	ASJ
Over 4 inches	2 inches	PFG	ASJ
Roof Drain Bodies and Bowls,			
4. Horizontal Down spout			
Pipe of all sizes	1 inch	PFG	ASJ
5.Horizontal Sanitary Waste Lines			
Pipe of all sizes	1 inch	PFG	ASJ
6.Condensate Drain Lines: (from Cooling Coil)			
Pipes of all sizes	3/4-inch	PFE	--
7.Boiler Breechings			
800°F pipe of all sizes (For 140°F surface)	3 inches	PCS	ALJ
8.Exhaust Pipe and Muffler For Emergency Generator			
1,200°F pipe of all sizes (For 140°F surface)	4 inches	PCS	ALJ

Note: Exhaust pipe and muffler insulation is only required at wall/roof penetrations and at all locations below 10'-0" for personnel protection.

C. For outdoor aboveground piping, increase insulation by 1/2 inch over listed indoor thickness, unless specified.
   1. Hot piping shall use ASJ with ALJ.
   2. Cold piping shall use ASJ with ALJ.

D. Pipe Insulation Methods:
   1. Pre-molded Fibrous Glass (PFG):
      a. Install insulation only when ambient temperature is between 40°F and 110°F.
      b. Make cuts and fabrications and clean insulation surface before removing protective strip from longitudinal seam adhesive lap. Do not leave adhesive strip exposed to air, dirt, or moisture. Adhere pressure-sealing lap immediately after removing protective strip. Use nylon sealing tool with sufficient pressure to assure positive and continuous seal.
      c. End joints shall be similarly sealed with factory furnished butt strip with integral pressure sealing adhesive. Butt strip material shall be the same as all-service jacket.
      d. Insulate pipefittings with FFI, field wrapped and tied glass fiber (1 pcf density wrapped firmly under compression, minimum 2 to 1) using pre-molded PVC fitting covers.
      e. Pre-molded straight pipe insulation shall not be cut and used as loose fill packing. Fitting insulation shall be the same thickness as adjacent insulation.
      f. Insulate valves, strainers, traps and flanges with molded pipe insulation of the same type and thickness as adjacent insulation, extended at least 2 inches over the adjacent pipe insulation, with the openings being filled with insulating cement. Finish with a jacket to match jacket on adjacent pipe.
      g. For pipe sizes 2 inches and smaller, insulation adjacent to valves, unions, strainers and traps shall be tapered back and neatly finished with glass cloth.
      h. For temperatures above 600°F, pre-molded insulation shall be applied in double layer with joints staggered. Inner layer shall be installed without jacket and

fastened with galvanized or stainless steel wire or bands at a maximum of 1'-0" on center.

2. PVC Preformed Insulation Fitting Covers and Jackets:
   a. Hot Systems: Provide insulated PVC fitting covers and jackets on pipe, fittings, flanges, valves and pipe terminations. The temperature of the PVC shall be kept below 125°F by the use of proper thickness of insulation and by keeping the PVC away from contact with, or exposure to, sources of direct or radiant heat.
      1) Fittings shall be insulated by applying the proper factory insert of insulation to the pipefitting. The ends of the insulation insert shall be tucked snugly into the throat of the fitting and the edges adjacent to the pipe insulation tufted and tucked in, fully insulating the pipefitting. The fitting jacket shall then be applied and secured by tack fastening, banding or taping the ends to the adjacent pipe insulation.
      2) On fittings where the operating temperature exceeds 250°F or where the pipe insulation thickness is greater than 1-1/2 inches, two or more layers of insulation inserts shall be applied prior to the installation of the PVC fitting jacket. The first layer shall be secured and compressed with a few wrappings of twine or fiberglass yarn to eliminate voids or hot spots. One additional insert shall be used for each additional 1 inch of pipe insulation above 1-1/2 inches.
      3) For high temperature installations, slip-joints shall be applied periodically between fixed supports and on continuous long runs of straight piping. Slip-joints shall be formed by increasing the amount of circumferential overlap to 8 to 10 inches and by applying a white flexible caulking in the overlap area to maintain a sealed system.
      4) On outdoor installations, seams and joints not sealed by vapor-barrier mastic shall have a pressure sensitive PVC tape applied.
   b. Cold Systems: Provide insulated PVC fitting covers and jackets on pipe, fittings, flanges, valves and pipe terminations.
      1) Applying the proper factory pre-formed insert of insulation to the pipefitting shall insulate fittings. The ends of the insulation insert shall be tucked snugly into the throat of the fitting and the edges adjacent to the pipe insulation tufted and tucked in, fully insulating the pipefitting.
      2) A vapor-retarded mastic compatible with the PVC shall be applied around the edges of the adjoining pipe insulation and on the fitting cover throat overlap seam. The PVC fitting jacket shall then be applied and shall be secured with pressure sensitive PVC tape along the circumferential edges and at seams not sealed by vapor barrier mastic. The tape shall extend over the adjacent pipe insulation and have an overlap on itself at least 2 inches on the downward side.
      3) On fittings where the operating temperature is below 45°F or where the pipe insulation thickness is greater than 1-1/2 inches, two or more layers of the insulation inserts shall be applied with the first layer being secured and compressed with a few wrappings of twine or fiber glass yarn to eliminate voids. One additional insert shall be used for each additional 1 inch of pipe insulation above 1-1/2 inches. An intermediate vapor retarded compatible with the PVC shall then be applied, completely sealing the insulation prior to installing the PVC fitting cover.
   c. PVC jacketing shall be applied over the pipe insulation where specified and shall overlap the fitting cover by approximately 1 inch. Adhesive shall be applied in the circumferential lap between the jacket and the fitting cover as well as along the longitudinal overlap of the jacket. Elastic cord or tape shall be used to hold the jacket in place until adhesive dries. Subsequent sections of the jacketing shall be applied as above with the appropriate amounts of circumferential and longitudinal overlap. Upon completion, seams shall be visually checked for sealing and touched up with adhesive where necessary.

d. PVC jackets and preformed insulation fitting covers shall be installed in strict accordance with the manufacturer's instructions.

3. Pre-molded Calcium Silicate (PCS):
   a. Wire insulation sections in place with 16-gage stainless steel wire on 9-inch centers, and minimum two wires per section.
   b. Insulate fittings with mitered segments wired in place. Using insulating cement, completely fill open joints and finish with 1/4-inch layer over entire surface. Cover with an aluminum jacket (ALJ) securely adhered with 3/4-inch stainless steel bands. All-service jacket (ASJ) shall not be used.
   c. Insulate valves and flanges with oversized pipe insulation sections.
   d. Insulation covers for valves and fittings shall be fabricated and installed according to manufacturer's recommended procedures. Insulate sweat and weld fittings with miter-cut pieces of the same material and thickness as the adjacent insulation. Insulate screwed fittings and valves with sleeve-fitting miter-cut covers of the same material and thickness as the adjacent insulation.
4. Aluminum Jacket (ALJ):
   a. Jacket shall be installed as insulation is installed to maintain dry insulation. Unjacketed insulation shall be protected from exposure to the elements.
   b. Install jacketing so that the longitudinal lap shall be at the 3 o'clock or 9 o'clock position to shed water, and transverse joints tightly overlapped minimum 6 inches to shed water and to minimize water penetration. Joints of jacketing shall be weather sealed by applying a preformed strap containing a permanently plastic weatherproof sealant or a 1/8-inch bead of sealant underneath the lap. Overflow of sealant shall be removed.
   c. Provide stainless steel screws or rivets maximum 6 inches on centers along longitudinal lap on hot piping, with stainless steel bands at each joint. Fasteners shall contact only the jacketing, not the piping.
   d. Provide stainless steel bands maximum 6 inches on centers along longitudinal laps on cold piping.
   e. At jacket expansion joints, secure with bands only, and seal with a flexible mastic.

3.3 EQUIPMENT INSULATION

A. General:
   1. Insulation shall be installed on equipment connected to insulated piping systems.
   2. Provide removable insulation sections to cover service access for equipment parts subject to periodic opening for maintenance.
   3. Access section of insulation shall be capable of removal and replacement with no insulation damage and shall include metal covers, fasteners, flanges, frames, and other required accessories.
   4. Service access sections shall be provided on heat exchanger heads, chiller evaporator heads, base mounted pumps, access openings in boilers and hot water heaters, and chiller condenser if a free-cooling cycle is used.
   5. Protective Jacketing:
      a. Equipment operating at a temperature at or above 100°F shall be jacketed with aluminum.
      b. Equipment operating indoors at a temperature below 100°F shall be jacketed with PVC excluding the condenser water sump and pump.

B. Equipment Insulation Schedule:

Equipment System Description	Minimum Thickness Insulation	Type of Insulation	Jacket Cover
1. Heating Water Systems (105°F to 200°F)			
Pumps	1-1/2 inches	SFG	ASJ

Cold Water break tanks	1-1/2 inches	SFG	ASJ
Compression/expansion tanks	1-1/2 inches	SFG	ASJ
Air separators	1-1/2 inches	SFG	ASJ
Chemical pot feeder's	1-1/2 inches	SFG	ASJ
Hot water converters	2 inches	SFG	ASJ

2. Chilled Water System

Pumps	See par. 3.3D	RFG&FFG	ALJ
Or	3/4-inch	FES	
Compression/expansion tanks	1-1/2 inches	SFG	ASJ
Air separators	1-1/2 inches	SFG	ASJ
Chemical pot feeder's	1-1/2 inches	SFG	ASJ
Heat Exchangers	1-1/2 inches	SFG	ASJ

3. Chillers

Water boxes and nozzles			
Cooler shell	1-inch	FES	--
Compressor suction housing	1-inch	FES	--
Suction elbow and piping	1-inch	FES	--

C. Equipment Insulation Methods:
   1. Semi-Rigid Fibrous Glass Blanket (SFG):
      a. Cut the insulation to such a length as to provide a snug fit around the surface to be insulated with a 2-inch jacket overlap at the end and longitudinal joints.
      b. Adhere the insulation with a fire resistant adhesive, applied such that the insulation conforms to the surface uniformly and firmly.
      c. Secure the ends and longitudinal joints with outward clinching staples on 6-inch centers and seal with a vapor barrier tape of the same material as the insulation jacket.
      d. At exposed edges, bevel-cut edge and finish with a 1/4-inch coat of insulating cement.
   2. Flexible Elastomeric Sheet (FES):
      a. Cut the insulation to provide a snug fit around the surface to be insulated and snug butt contact of end and longitudinal joints.
      b. Adhere the insulation to the surface uniformly and firmly with 100 percent coverage of contact adhesive.
      c. Secure the joints and seams with a contact adhesive.

D. Chilled Water Pumps and Plate and Frame Heat Exchangers:
   1. Insulate with removable and replaceable covers consisting of No. 20 gauge aluminum sheets metal jacket lined with a minimum of 2" thick RFG board insulation. All voids between the insulation and the pump housing shall be filled with FFG insulation. Closure joints of the metal casing shall be vapor sealed after the covers are in place. The covers shall be provided with heavy-duty draw pull latches (see McMaster Carr. Page 729 Figure 1590A11.

3.4 DUCTWORK INSULATION

A. General:
   1. Seal joints, cracks, and breaks (including holes for the fasteners) in the vapor barrier with a vapor barrier mastic and vapor barrier jacket material similar to the vapor barrier jacket on the rest of the insulation. Seal breaks in the vapor barrier caused by the attachment of tubing or control devices. Apply mastic at the rate recommended by the manufacturer. Pressure sensitive tape, self-sealing laps, or other types of factory-applied adhesive of any kind shall not be permitted.

2. Cover the standing seams, hangers, and other protrusions on the ducts that are insulated, with an insulating board.
3. On outdoor air intake ducts, a 6 inch wide piece of 2 pcf density fibrous glass board shall be inserted between the duct and duct channel hangers for hanger support. The board shall be covered with a vapor barrier jacket to match the duct insulation, and shall be fully sealed with vapor barrier mastic to form a vapor proof seal.
4. Insulation sections over access panels shall be easily removable. Provide metal corner beads on edges of removable sections and insulation openings around access panels.
5. Install the insulation such that access to and operation of manual and automatic damper operators is not impeded. Provide sheet metal standoffs full depth of the insulation for duct-mounted devices, such as damper operators, etc. Seal to maintain vapor barrier on cold ducts.
6. Duct insulation shall be applied to ductwork that has been internally lined. However, the insulation thickness may be reduced by one-half of the lining thickness.
7. For insulation purposes, a conditioned space shall be defined as one that is mechanically heated and cooled to maintain temperatures having a range from 65°F to 75°F (dry bulb).

B. Duct Insulation Schedule:

System Description	Minimum Insulation Thickness	Type of Insulation	Jacket Cover
1. Ventilating and Air Conditioning Systems			
a. Supply Duct (S.A.T. 45°F to 105°F):			
1) Exposed in a conditioned space	none	none	none
2) Exposed in mechanical rooms			
Rectangular	2 inches	RFG	FSK
Round or oval	2 inches	SFG	FSK
3) Concealed in shafts or Suspended ceilings adjoining a conditioned space	2 inches	FFG	FSK
b. Process Make up air ducts (S.A.T. 45°F to 70°F, 35% - 45% RH):			
1) From Make-up AHU to re-circulating air handler or plenum	2 inches	RFG	FSK
2) Outdoor ductwork	3 inches	RFG	FSK
c. Return and Exhaust Ducts (R.A.T.60°F to 90°F):			
1) Exposed in conditioned space	none	none	none
2) Exposed in mechanical rooms			
Rectangular	1-1/2 inches	RFG	FSK
Round	1-1/2 inches	SFG	FSK
3) Concealed in shafts or suspended ceilings adjoining a conditioned space	none	none	none
4) Concealed in shafts or suspended ceilings adjoining an unconditioned space	2 inches	FFG	FSK
2. Outside Air Intake Ducts (20°F to 130°F):			
a. Concealed in shafts or above suspended ceilings	2 inches	FFG	FSK
b. Exposed in mechanical room			
Rectangular	2 inches	RFG	FSK
Round or oval	2 inches	SFG	FSK
3. Louver Blank-Offs and Plenums (single thickness)	2 inches	RFG	FSK

C. Duct Insulation Methods:

1. Flexible Fibrous Glass Blanket (FFG):
   a. Cut the insulation slightly longer than the duct circumference to provide full thickness at the corners.
   b. Install the insulation such that it conforms to the duct surfaces uniformly and firmly. Insulation on ducts over 18 inches wide shall further be secured to the duct bottom with welded pins and speed clips on 18 inch maximum centers both ways. Clip off pin projections flush to clips. Insulation on vertical duct risers shall be secured on 12-inch maximum centers on all sides of duct.
   c. Butt the insulation with facing overlapping end and longitudinal joint seams by 2 inches minimum. Longitudinal seams shall be stapled on 2-inch centers and then sealed with pressure-sensitive foil vapor barrier tape. Seal pin penetrations, cuts,

and tears in the vapor barrier with strips of vapor barrier tape to match insulation jacket.

2. Semi-Rigid Fibrous Glass Blanket (SFG):
   a. Before applying the duct wrap, sheet metal duct shall be clean, dry and sealed at joints (including corners) and seams.
   b. Prepare the overlap by removing approximately 2 inches of insulation from the facing.
   c. Wrap the insulation around the duct with facing to the outside so the 2-inch flap completely overlaps the facing and insulation at the other end of stretch out. Insulation shall be snugly butted.
   d. Seams shall be stapled approximately 6 inches on center with outward clinching staples, then sealed with pressure-sensitive tape matching the facing and designed for use with the duct insulation. The underside of ductwork 24 inches or greater shall be secured with mechanical fasteners and speed clips spaced approximately 18 inches on center. The protruding ends of the fasteners shall be cut off flush after the speed clips are installed, and then sealed with the same tape as specified above. Insulation on vertical duct risers shall be secured on 12 inch maximum centers on all sides of duct.
   e. Adjacent sections of duct wrap insulation shall be snugly butted with the circumferential 2-inch tape flap overlapping and secured as recommended for longitudinal seam. In lieu of pressure sensitive tape, two coats of vapor-retarded mastic reinforced with one layer of 4 inch wide open weave glass fabric may be used.
   f. Insulate fittings with mitered sections of insulation of the same type and thickness as adjacent sections. Using insulating cement, fill open joints then cover entire fitting with 1/4-inch thick topcoat. Trowel surface smooth and apply a glass cloth cover with quick setting cement.
3. Rigid Fibrous Glass Board (RFG):
   a. Apply the insulation with edges tightly butted. Impale insulation on welded pins on 12-inch centers both ways and secure with speed clips. Clip off pin projections. Seal the joints and vapor barrier penetrations with pressure-sensitive vapor barrier tape identical to the insulation jacket. Cover each speed clip with the same vapor barrier tape.

END OF SECTION 15250